With regards of the author

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ALPINE

AND

ARCTIC PLANTS:

A LECTURE

DELIVERED BEFORE THE YOUNG MEN'S CHRISTIAN ASSOCIATION OF MONTREAL,

February, 1862.

BY

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MONTREAL:
PRINTED BY JOHN LOVELL, ST. NICHOLAS STREET.
1862.

ALPINE AND ARCTIC PLANTS.

In selecting a subject of lecture for this occasion, my first impulse would have been to have taken some of those higher topics bearing on the evils of this erring world, and the remedies for them provided in the glorious gospel contained in God's Holy Word; but circumstances have rendered it expedient to content myself with one of the humbler subjects to which much of my own time is necessarily devoted, and which I trust may not prove uninteresting or uninstructive. I shall ask your attention for a little while to some alpine plants of the White Mountains of New Hampshire, which I visited in their native haunts in my last summer vacation.

The group of the White Mountains is the culminating point of the northern division of the great Appalachian range, extending from Tennessee to Gaspé in a south-west and north-east direction, and constituting the breast-bone of the North American continent. This great ridge or succession of ridges has its highest peaks near its southern extremity, in the Black Mountains; but these are little higher than their northern rivals, which at least hold the undisputed distinction of being the highest hills in north-eastern America. As Guyot * has well remarked, the White Mountains do not occur in the general line of the chain, but rather on its eastern side. The central point of the range, represented by the Green Mountains and their continuation, describes a great curve from Gaspé to the valley of the Hudson, and opposite the middle of the concave side of this curved line towers the almost isolated group of the White Hills. On the other side is the narrow valley of Lake Champlain, and beyond this the great isolated mass of the Adirondack Mountains, nearly approaching in the altitude of their highest peaks, and greatly exceeding in their geological

* Silliman's Journal.

age, the opposite White Mountain group. The Appalachian range is thus in this part of its course, supported on either side by outliers higher than itself.

My present purpose is not to give a general geographical or geological sketch of the White Mountains, but to direct attention to the vegetation which clothes their summits, and its relation to the history of the mountains themselves. For this purpose I may first shortly describe the appearances presented in ascending the highest of them, Mount Washington, and then turn to the special points to which these notes relate.

In approaching Mount Washington by the Grand Trunk Railway, the traveller has ascended from the valley of the St. Lawrence to a height of 802 feet at the Alpine House at Gorham. Thence in a distance of about 8 miles along the bank of the Peabody River, to the Glen House, he ascends to the elevation of 1632 feet above the sea; and it is here or immediately opposite the Glen House, that the actual ascent begins. The distance from the Peabody River, opposite the hotel, to the summit is nine miles, and in this distance we ascend 4656 feet, the total height being 6288 feet above the sea.* Formerly only a bridle path led up this ascent; but last year a regularly graded and admirably finished carriage road was opened, by which visitors can drive comfortably to the top and back without any of the fatigue formerly experienced. This enterprise, almost worthy of comparison with the great roads over the passes of the Alps, was undertaken several years ago by a joint-stock company, and has at length been finished, at a cost, I believe, of $40,000, the interest on which it is hoped will be paid by the tolls levied on travellers, whose annual numbers are estimated at about 5000 for this road. This royal road to the summit is however by far too democratic for the taste of some visitors, who mourn the olden days of ponies, guides, and adventures; and though it gives an excellent view of the geological structure of the mountain, it does not afford a good opportunity for the study of the alpine flora, which is one of the chief attractions of Mount Washington. For this reason, though I availed myself of the new road for gaining a general idea of the features of the group, I determined to ascend by Tuckerman's ravine, a great chasm in the mountain side, named in honour of the indefatigable botanist of the North American

* According to Guyot, but some recent surveys make it a little higher.

lichens.* I was aided in this by the kindness of a gentleman of Boston, well acquainted with these hills, and passionately fond of their scenery. Our party, in addition to this gentleman and myself, consisted of two ladies, two children, and two experienced guides, whose services were of the utmost importance, not only in indicating the path, but in removing windfalls and other obstructions, and in assisting members of the party over difficult and dangerous places.

We followed the carriage road for two miles, and then struck off to the left by a bridle path that seemed not to to have been used for several years—the gentlemen and guides on foot, the ladies and children mounted on the sure-footed ponies used in these ascents. Our path wound around a spur of the mountain, over rocky and uneven ground, much of the rock being mica slate, with beautiful cruciform crystals of andalusite, which seemed larger and finer here than in any other part of the mountain which I visited. At first the vegetation was not materially different from that of the lower grounds, but as we gradually ascended we entered the "overgreen zone," and passed through dense thickets of small spruces and firs, the ground beneath which was carpeted with moss, and studded with an immense profusion of the delicate little mountain wood-sorrel (*Oxalis acetosella*), a characteristic plant of wooded hills on both sides of the Atlantic, and which I had not before seen in such profusion since I had roamed on the hills of Lochaber Lake in Nova Scotia. Other herbaceous plants were rare, except ferns and club-mosses; but we picked up an aster (*A. acuminatus*), a golden rod, (*Solidago thyrsoidea*), and the very pretty tway blade (*Listera cordata*).

In ascending the mountain directly, the spruces of this zone gradually degenerate, until they present the appearance of little gnarled bushes, flat on top and closely matted together, so that except where paths have been cut, it is almost impossible to penetrate among them. Finally they lie flat on the ground, and become so small that, as Lyell remarks, the rein-deer moss may be seen to overtop the spruces. This dwarfing of the spruces and firs is the effect of adverse circumstances, and of their struggle to extend their range toward the summit. Year by year they

* Peck, Bigelow and Booth were the early botanical explorers of the White Mountains; though Pursh was the first to determine some of the more interesting plants, and Oakes and Tuckerman deserve honourable mention, as the most thorough modern explorers.

stretch forth their roots and branches, bending themselves to the ground, clinging to the bare rocks, and availing themselves of every chasm and fissure that may cover their advance: but the conditions of the case are against them. If their front advances in summer it is driven back in winter, and if in a succession of mild seasons they are able to gain a little ground, less favourable seasons recur, and wither or destroy the holders of their advanced positions. For thousands of years the spruces and firs have striven in this hopeless escalade, but about 4000 feet above the sea seems to be the limit of their advance, and unless the climate shall change, or these trees acquire a new plasticity of constitution, the genus *Abies* can never displace the hardier alpine inhabitants above, and plant its standard on the summit of Mount Washington.

I was struck by the similarity of this dwarfing of the upper edges of the spruce woods, to that which I have often observed on the exposed northern coasts of Cape Breton and Prince Edward Island, where the woods often gradually diminish in height toward the beach or the edge of a cliff, till the external row of plants clings closely to the soil, or rises above it only a few inches. The causes are the same, but the appearance is more marked on the mountain than on the coast.

On the path which we followed, before we reached the upper limit of trees, we arrived at the base of a stupendous cliff, forming the termination of a promontory or spur of the mountain, separating Tuckerman's ravine from another deep depression known as the Great Gulf. From the top of this precipice poured a little cascade that lost itself in spray long before it touched the tops of the trees below. The view at this place was the most impressive that it was my fortune to see in these hills.

Opposite the mouth of the Great Gulf, and I suppose at a height of about 3000 feet, is a little pond known as Hermit Lake. It is nearly circular, and appears to be retained by a ridge of stones and gravel, perhaps an old moraine or sea beach. On its margin piped a solitary sand-piper, a few dragon flies flitted over its surface, and tadpoles in the bottom indicated that some species of frog dwells in its waters. High over head and skirting the edges of the precipices, soared an eagle, intent no doubt on the hares that frequent the thickets of the ravines.

Before we reached Hermit Lake we had been obliged to leave our horses, and now we turned aside to the left and entered

Tuckerman's ravine, where there is no path, but merely the bed of a brook, whose cold clear water tumbles in a succession of cascades over huge polished masses of white gneiss, while on both sides of it the bottom of the ravine is occupied by dense and almost impenetrable thickets of the mountain alder (*Alnus viridis.*)

Tuckerman's ravine has been formed originally either by a subsidence of a portion of the mountain side or by the action of the sea. It is, like most of the ravines and "gulfs" of these hills, a deep cut or depression bounded by precipitous sides, and terminating at the top in a similarly precipitous manner. It must at one period have been in part filled with boulder clay, steep banks of which still remain in places on its sides; and extensive landslips have occurred, by which portions of the limiting cliffs have been thrown toward the centre of the valley, in large piles of angular blocks of gneiss and mica slate, in the spaces between which grow gnarled birches and spruces that must be used as ladders and bridges whereby to scramble from block to block, by every one who would cross or ascend one of these rivers of stones.

At the head of the ravine we paused to rest, to admire the wild prospect presented by the ravine and its precipitous sides, and to collect the numerous plants that flower on the surrounding slopes and precipices. Here on the 19th of August were several large patches of snow, one of them about an hundred yards in length. From the precipice at the head of the ravine, poured hundreds of little rills, and several of them collecting into a brook, had excavated in the largest mass of snow a long tunnel or cavern with an arched and groined roof. Under the front of this we took our mid-day meal, with the hot August sun pouring its rays in front of us, and icy water gurgling among the stones at our feet. Around the margin of the snow the vegetation presented precisely the same appearances which are seen in the low country in March and April, when the snow banks have just disappeared—the old grass bleached and whitened, and many perennial plants sending up blanched shoots which had not yet experienced the influence of the sunlight.

The vegetation at the head of this ravine and on the precipices that overhang it, presents a remarkable mixture of lowland and mountain species. The head of the ravine is not so high as the limit of trees already stated, but its steep sides rise abruptly to a plateau of 5000 feet in height intervening between Mount Wash-

ington and Mount Munro, and on which are the dark ponds or tarns known as the Lakes of the Clouds, forming the sources of the Amonoosook river, which flows in the opposite direction. From this plateau many alpine plants stretch downward into the ravine, while lowland plants availing themselves of the shelter and moisture of this cul-de-sac, climb boldly upward almost to the higher plateau. Other species again occur here which are found neither on the exposed alpine summits and ridges nor in the low country. Conspicuous among the hardy climbers are two coarse and poisonous weeds of the river valleys, that look like intruders into the company of the more dwarfish alpine plants;—the cow-parsnip (*Heracleum lanatum*) and the white hellebore (*Veratrum viride*). Both of these plants were seen struggling up through the ground at the margin of the snow, and climbing up moist hollows almost to the top of the precipices. Some specimens of the latter were crowded with the infant caterpilars of a mountain butterfly or moth. Less conspicuous, and better suited to the surrounding vegetation, were the bluets (*Oldenlandia cœrulea*), now in blossom here as they had been months before in the low country, the dwarf cornel (*Cornus Canadensis*), and the twin-flower (*Linnæa borealis*), the latter reaching quite to the plateau of the Lake of the Clouds, and entering into undisputed companionship with the truly alpine plants, though it is also found at Gorham four thousand feet lower.

Of the plants which seemed to be confined or nearly so to the upper part of the ravine, one of the most interesting was the northern painted cup, (*Castelleia septentrionalis*) a plant which abounds on the coast of Labrador and extends thence through all Arctic North America to the Rocky Mountains, and is perhaps identical with the *C. Sibirica* of Northern Asia and the *C. pallida* of Northern Europe. Large beds of it were covered with their pale yellow blossoms on the precipitous banks overhanging the head of the ravine. With the painted cup and here alone, was another beautiful species of a very different order, the northern green orchis, (*Platanthera hyperborea*) a plant which occurs, though rarely, in Canada, but is more abundant to the northward. Here also occurred Peck's geum, (*G. radiatum, var.*), *Arnica mollis*, and several other interesting plants.

Of the Alpine plants which descend into the ravine, the most interesting was the Greenland sandwort, (*Arenaria* (*Alsine*) *Groenlandica*) which was blooming abundantly, with its clusters

of delicate white flowers, on the very summit of the mountain, and could be found here and there by the side of the brook in the bottom of the ravine.

Clambering by a steep and dangerous path up the right side of the ravine, we reach almost at once the limit beyond which the ordinary flora of New England can extend no longer, and are in the presence of a new group of plants comparable with those of Labrador and Greenland. Here, on the plateau of the Lake of the Clouds, the traveller who has ascended the giddy precipices overhanging Tuckerman's ravine, is glad to pause that he may contemplate the features of the new region which he has reached. We have left the snow behind us, except a small patch which lingers on the shady side of Mount Munro; for it is only in the ravines into which it has drifted an hundred feet deep or more, that it can withstand the summer heat until August. We stand on a dreary waste of hard angular blocks of mica slate and gneiss, that lie in rude ridges as if they had been roughly raked-up by Titans who might have been trying to pile Monro upon Washington; but which seem to be merely the remains of the original outcropping edges of the rocks broken up by the frost, but not disturbed or rounded by water. Behind us is the deep trench-like ravine out of which we have climbed: on the left hand a long row of secondary summits stretching out from Mount Washington to the south-westward, and designated by the names of a series of American statesmen. In front this range descends abruptly in great wooded spurs or buttresses to the valley of the Amonoosook which shines in silvery spots through the trees far below. On our right hand towers the peak of Mount Washington, still more than a thousand feet above us, and covered with angular blocks, as if it were a pile of fragments rather than a solid rock. These stones all around and up to the summit of the mountain, are tinted pale green by the map lichen (*Lecidea Geographica*) which tinges in the same way the alpine summits of European mountains. Between the blocks and on their sheltered sides nestle the alpine flowering plants, of which 20 species or more may be collected on this shoulder of the mountain, and some of which extend themselves to the very summit, where *Alsine Grœnlandica* and the little tufts of deep green leaves of *Diapensia Lapponica* with a few Carices seem to luxuriate. Animal life accompanies these plants to the summit, near which I saw a family of the snow bird (*Plectrophanes nivalis,*) evidently summer residents

here, and a number of insects, conspicuous among which was a brown butterfly of the genus *Hipparchia*. Shortly before sundown, when the thermometer at the summit house was fast settling toward the freezing point, a number of swallows were hawking for flies at a great height above the highest peak. To what species they belonged I could not ascertain. Possibly the cliff swallows find breeding places in the sides of the ravines, and rise over the hill top to bask in the sunbeams, after the mountain has thrown its shadows over their homes.

To return to the alpine flora which is peculiar to the peaks of these mountains—are the species comprising it autochthones originating on these hill tops and confined to them, or are they plants occurring elsewhere, and if so where; and how and when did they migrate to their present abodes? These are questions which must occur to every one interested in geology, botany, or physical geography. They have been answered in various ways; but without entering into controversy, I shall merely state a few facts, bearing on and illustrating that view which I myself prefer.

Not one of the alpine plants of Mount Washington is peculiar to the place. Nearly all of them are distinct from the plants of the neighboring lowlands, but they occur on other hills of New England and New York, and on the distant coasts of Labrador and Greenland, and some of them are distributed over the Arctic regions of Europe, Asia and America. In short they are stragglers from that Arctic flora which encompasses the north polar region, and extends in promontories and islands, along the high cold mountain summits far to the southward.

Some of the humble flowerless plants of these hills are of nearly world wide distribution. I have already noticed the pale green map lichen which tints the rocks of the Pyrenees, the Alps, and the Scottish Highlands; and the curious ring lichen (*Parmelia centrifuga*) paints its conspicuous rings and arcs of circles alike on Mount Washington and the Scottish hills. A little club moss (*Lycopodium selago*) is not only widely distributed over the northern hemisphere, but Hooker has recognised it in the Antarctic regions. Not long ago we unrolled in Montreal an Egyptian mummy preserved in the oldest style of embalming, and found that, to preserve the odour of the spices, quantities of a lichen (*Evernia furfuracea*) had been wrapped around the body and had no doubt been imported into Egypt from Lebanon or the hills of Macedonia for such uses. Yet the specimens

from this old mummy were at once recognised by Professor Tuckerman as identical with this species, as it occurs on the White Hills and on Katahdin in Maine. These facts are however easily explicable in comparison with those that relate to the flowering plants.

The spores of lichens and mosses float lighter than the lightest down in the air, and may be wafted over land and sea, and dropped everywhere to grow where conditions may be favourable. Had the Egyptian embalmer used some of the first created specimens of *Evernia furfuracea*, it might easily within the three thousand years or so since his work was done, have floated round the world and established itself on the White Hills. But, as we shall see, neither the time nor means would suffice for the flowering plants. The only available present agency for the transmission of these would be in the crops or plumage of the migratory birds; and when we consider how few of these on their migrations from the north could ever alight on these hills, and the rarity of their carrying seeds in a state fit to vegetate, and further that few of these plants produce fruits edible by birds, or seeds likely to attach themselves to their feathers, the chances become infinitely small of their transmission in this way. The most profitable course of investigation in this and most other cases of apparently unaccountable geographical distribution, is to inquire as to the past geological conditions of the region, and how these may have affected the migrations of plants.

The earlier geological history of these mountains far antedates our existing vegetation. It belongs in the first instance to the Lower Devonian period, in which the materials of these mountains were accumulating, as beds of clay and gravel, in the sea bottom. These were buried under great depths of newer deposits, and were baked and metamorphosed into their present crystalline condition. Again heaved above the sea level, they were hewn by the action of the waves to some degree into their present forms, and constituted part of the nucleus of the American continent in the tertiary period. They were again with all the surrounding land depressed under the sea in the newer Pliocene period, and in the Post-pliocene or modern, slowly upheaved again to their present height. These last changes are those that concern their present flora, and their relations to it are well stated by Sir C. Lyell in the following passages from his interesting account of his ascent of Mount Washington in 1846.

"If we attempt to speculate on the manner in which the peculiar species of plants now established on the highest summits of the White Mountains, were enabled to reach those isolated spots, while none of them are met with in the lower lands around, or for a great distance to the north, we shall find ourselves trying to solve a philosophical problem which requires the aid not of botany alone but of geology, or a knowledge of the geographical changes which immediately preceded the present state of the earth's surface. We have to explain how an Arctic flora consisting of plants specifically identical with those which inhabit lands bordering the sea in the extreme north of America, Europe and Asia, could get to the top of Mount Washington. Now geology teaches us that the species living at present on the earth are older than many parts of our existing continents; that is to say they were created before a large portion of the existing mountains, valleys, plains, lakes, rivers, and seas were formed. That such must be the case in regard to Sicily, I announced my conviction in 1833, after first returning from that country, and a similar conclusion is no less obvious to any naturalist who has studied the structure of North America, and observed the wide area occupied by the modern or glacial deposits, in which marine shells of living but northern species are entombed. It is clear that a great portion of Canada, and the country surrounding the great lakes, was submerged beneath the ocean when recent species of mollusca flourished, of which the fossil remains occur about 500 feet above the level of the sea at Montreal. Lake Champlain was a gulf or strait of the sea at that period, large areas in Maine were under water, and the White Mountains must then have constituted an island or group of islands. Yet as this period is so modern in the earth's history as to belong to the epoch of the existing marine fauna, it is fair to infer that the Arctic flora now contemporary with this was then also established on the globe.

"A careful study of the present distribution of animals and plants over the globe, has led nearly all the best naturalists to the opinion that each species had its origin in a single birth-place, and spread gradually from its original centre to all accessible spots fit for its habitation, by means of the powers of migration given to it from the first. If we adopt this view, or the doctrine of specific centres, there is no difficulty in comprehending how the *Cryptogamous* plants of Siberia, Lapland, Greenland, and Labrador, scaled the heights of Mount Washington, because the

sporules of the fungi, lichens, and mosses, may be wafted through the air for indefinite distances like smoke; and in fact heavier particles are actually known to have been carried for thousands of miles by the wind. But the cause of the occurrence of Arctic plants of the *Phænogamous* class on the top of the New Hampshire Mountains, specifically identical with those of remote polar regions, is by no means so obvious. They could not in the present condition of the earth affect a passage over the intervening lowlands, because the extreme heat of summer and cold of winter would be fatal to them. We must suppose, therefore, that originally they extended their range in the same way as the plants now inhabiting arctic and antarctic lands disseminate themselves. The innumerable islands in the polar seas are tenanted by the same species of plants, some of which are conveyed as seeds by animals over the ice when the sea is frozen in winter, or by birds; while a still larger number are transported by floating icebergs, on which soil containing the seeds of plants may be carried in a single year for hundreds of miles. A great body of geological evidence has now been brought together to show that this machinery for scattering plants as well as for carrying erratic blocks southward, and polishing and grooving the floor of the ancient ocean, extended in the western hemisphere to lower latitudes than that of the White Mountains. When these last still constituted islands in a sea chilled by the melting of floating ice, we may assume that they were covered entirely by a flora like that now confined to the uppermost or treeless region of the mountains. As the continent grew by the slow upheaval of the land, and the islands gained in height, and the climate around these hills grew milder, the Arctic plants would retreat to higher and higher zones, and finally occupy an elevated area which probably had been at first or in the glacial period, always covered with perpetual snow. Meanwhile the newly formed plains around the base of the mountain, to which northern species of plants could not spread, would be occupied by others migrating from the south, and perhaps by many trees, shrubs, and plants, then first created, and remaining to this day peculiar to North America."

The time to which the above views of Sir C. Lyell would refer the migration of the White Mountain flora, is historically very remote. The changes of level which have submerged the American continent and re-elevated its land, have occupied long periods. Whether with Lyell we measure these periods by the recession

of the Falls of Niagara, or by the growth of the alluvial plain of the Mississippi; or with Agassiz, by the extension of the Peninsula of Florida, or endeavour to estimate the time required for the abrasion and deposition of the great mass of clay that fills the valley of the St. Lawrence, we cannot suppose that less than two or three hundred centuries have elapsed since the alpine plants of the White Mountains were cut off from all connection with their Arctic relatives. Their reign upon the mountain tops not only antedates all human dynasties, but reaches beyond the creation of man himself and many of his contemporaries.

Positive evidence of the existence of some of these plants during a large portion of this lapse of time, has actually been preserved in the Post-pliocene deposits of Canada. At Green's Creek on the Ottawa, in nodules in the clay containing marine shells, and coeval with the Leda clay of Montreal, there are numerous remains of plants that have been embedded in this clay at a time when the Ottawa valley was a bay or estuary, and when the Adirondack Mountains of New York and the mountains of New England were two rocky islands separated from each other, and from the mainland on the north, by wide arms of the sea. The plants found in these nodules all appear to be of modern species. It is of course not easy to recognise the specific characters in these fragments, but I think I have good evidence of *Potentilla Norvegica*, *P. tridentata*, and possibly *P. Canadensis; Populus balsamifera*, *Arctostaphylos uva-ursi*, *Trifolium repens*, *Drosera rotundifolia*, *Potamogeton natans*, and *P. perfoliatum*.* There are also seeds apparently of ranunculaceous plants; grasses and carices, and mosses. Several of these plants are found on the White Mountains, and they are all northern and arctic species. I have no doubt that further examination of these deposits will lead to the discovery of additional examples. This fact, proving as it does the existence of these species at the period in which the theory of Lyell and Forbes requires them to have migrated, is in itself strong corroborative evidence. We can say that some of these species were waiting on the shores of the north, ready to be drifted to the insular spots to the south-west, and that their seeds were actually being washed out to sea by the streams which emptied themselves into the then estuary of the Ottawa.

* These determinations were made from specimens in the collection of the Geological Survey, and from others kindly collected for me by A. Dickson, Esq.

Another aspect of the inquiry which has perhaps not been regarded with sufficient attention, is that which relates to the reduction of temperature, which might be consequent on the great depression of the land which we know to have existed at the close of the tertiary period, a fact on which I have insisted in former papers on the Post-pliocene deposits of Canada.* A very clever writer on the subject of geographical distribution,† has pictured the case of a subsiding continent with the fauna and flora of its lowlands becoming gradually concentrated on the spots which had previously been alpine summits, but now reduced to low and temperate islands. But he has left out of view the fact, that if land still existed in mass in the arctic regions, and if the subsidence was that of land in temperate regions, then on the principles long ago so well stated by Sir C. Lyell, these islands might have a mean temperature far below that of the former plains, and might in consequence be suitable only to such an alpine flora as that which they had previously borne.

Now this is precisely what occurred in the Post-pliocene period. The arctic land remained in great mass, detaching into the sea annual crops of icebergs, which have strewed all the northern hemisphere with boulders : the temperate regions were submerged except a few insular spots. These are the very conditions required for a low mean temperature both in the sea and on the land, and these geographical conditions correspond precisely with the facts as indicated by the fossil animals and plants of the period.

Further, it would be easy to show that the alpine plants of Mount Washington would thrive under such conditions as those supposed, at the sea level ; a low and equable temperature with a moist atmosphere being that which they most desire, and their greatest enemy being the dry parching heat of the plains of the temperate regions. Those of them, such as *Potentilla tridentata* and *Alsine Grœnlandica*, which occur in low ground within the limits of the United States, are found under shaded woods, in damp ravines, or on the moist sea coast ; and as we follow the coasts northward, we find these plants on these and on neighboring islands, in lower latitudes than those in which they occur inland. When the summer mists roll around the summit of Mount Washington, it is in every respect the precise counterpart of an

* Canadian Naturalist, Vol. IV. † Wollaston.

islet anywhere on the coast of America from Cape Breton to the arctic seas, and when winter wraps everything in a mantle of snow, all these lands are in like manner under the same conditions. So in the Post-pliocene period, though the islets of the White Mountains may have experienced a less degree of winter cold, they must have had very nearly the same summer temperature as now; and as this is the season of growth for our alpine and arctic plants, it is its character that determines the suitableness of the locality to them.

Those stupendous vicissitudes of land and water which have changed the aspect of continents, and swept into destruction races of gigantic quadrupeds, have dealt gently with these alpine plants, which long ages ago looked out upon a waste of ice-laden waters that had engulfed the Pliocene land with all its inhabitants, as securely as they now look down upon the pleasant valleys of New England. It is curious too that the humbler tenants of the sea have shared a similar exemption. In the clay banks of the Saco, on the shores of Lake Champlain, and mixed with the remains of these very plants in the valley of the Ottawa, are shells that now live in the Gulf of St. Lawrence and on the coast of Maine, intermixed with other species that are now found only in a few bays of the Arctic seas. Just as in the Post-pliocene clays of the Ottawa, the remains of arctic plants are found in the same nodule with those of *Leda truncata*, so now similar associations may be taking place on the coasts at the mouth of the Great Fish River. Truly, in nature as in grace, God hath chosen the weak things of the world to confound those that are mighty, and has left in the earth's geological history, monuments of his respect and regard for the humblest of his works.

We look in vain among the alpine plants so long isolated in these mountains, for any evidence of decided change in specific characters. The alpine plants for ages separated from their arctic brethren, are true to their kinds, and shew little tendency to vary, and none to adapt themselves to new forms in the sunny plains below. This is especially noteworthy in Mount Washington and the neighboring peaks, because the soil of these is the same with that of the valleys below. Several of the plants peculiar to these hills, as the black crow-berry (*Empetrum nigrum*), for instance, even when other conditions are favourable, shun rich calcareous soils, and affect those of granitic origin. In many cases the difference in soil is a sufficient reason for the non-occurrence

of such plants except on certain hills. At Murray Bay, and on the shores of Lake Superior, the plant above named occurs only on the Laurentian gneiss. In Nova Scotia, its relative, *Corema Conradi*, is confined to the granite barrens of the south coast. Many such plants skirt the whole Laurentian range from Labrador to Lake Superior, but refuse to extend themselves over the calcareous plains of Canada. But in the White Hills the soil of the river alluvium is the same micaceous sand that fills the crevices of the rocks in the mountains, and hence there is no obstruction, in so far as soil is concerned, to the diffusion of plants upward and downward in the hills. In like manner there is every possible condition as to moisture and dryness, sunshine and shade, in both localities. These circumstances are of all others the most favourable to such variation as these plants are capable of undergoing. The case is the same with that which Hugh Miller so strongly puts in relation to the species of algæ that occur at different distances below high water mark on the coast of Scotland, each species there attaining a certain limit, and then instead of changing to suit the new conditions, giving place to another. So it is on Mount Washington; and this whether we regard the lowland plants that climb to a certain height and there stop; the plants that are common to the base and summit, or the plants that are confined to the latter.

I have already referred to the evident struggle of the spruces and firs, and the plants associated with them, to ascend the mountain; and the same remark applies to all the plants that one after another cease to appear at various heights from the lower valleys. One by one they become stunted and depauperated, and then cease, without any semblance of an attempt to vary into new and hardier forms. And this must have been proceeding, be it observed, from all those thousands or myriads of years that have elapsed since the elevation of the mountains out of the glacial seas. It is to be observed also that the new plants that occur in ascending, often belong to different genera and families from those left behind, not to closely allied species; and in the few cases in which this last kind of change occurs, there is no graduation into intermediate forms. For instance *Solidago thyrsoidea* and *S. virga-aurea* occur around the base of the mountain, and for some distance up its sides. At the height of four to five thousand feet, the latter only remains, and this in a dwarfish condition. This corresponds to its distribution elsewhere, for according to Richardson it occurs in

lat. 55° to 65° in Arctic America, and according to Hooker it is found in the Rocky Mountains, while it also occurs in the hills of Scotland, and very abundantly in some parts of Norway. In the White Mountains *S. thyrsoidea* prevails toward the base, *S. virga-aurea* toward the summit; and at the top of Tuckerman's ravine I found the former of these golden-rods in blossom, within a few hundred feet of the latter, each preserving its distinctive peculiarities. Much has lately been said of the appearance of specific diversity that results from the breaking up of the continuity of the geographical areas of plants by geological changes; but here we probably have the converse of this. The mountain species is no doubt a part of the older arctic flora, the other perhaps belongs to a more modern flora, and they have met on the sides of the White Hills.

Some hardy species climb from the plains to heights of 5000 feet or more, with scarcely even the usual change of being depauperated, and then suddenly disappear. This is very noteworthy in the case of two woodland plants, the dwarf cornel or pigeon-berry (*Cornus Canadensis*), and the twin-flower (*Linnæa borealis*). The former of these is a plant most widely distributed over northern America, and probably belongs to that newer flora which overspread the continent after its re-elevation. In August this plant in the woods around the base of Mount Washington is loaded with its red berries. At an elevation of four to five thousand feet it may be found in bloom; above this a few plants appear destitute of flowers, dwarfish in aspect, and nipped by cold, and then the species disappears. No doubt the birds that feed on its little drupes have carried it up the mountain, and have sown it a little farther up than the limit of its probable reproductiveness. The beautiful little *Linnæa* is a still more widely distributed plant; for it occurs on the hills of northern Europe, and is found across the whole breadth of the American continent from Nova Scotia to the Columbia River. It is almost beyond question a member of the old arctic flora which colonised the islands of the Post-pliocene sea, and has descended from them on all sides as the land became elevated. This plant also climbs Mount Washington to a height of 5000 feet, and presents precisely the same characters on the top as at the bottom, only losing a little in the length of its stem. Specimens bearing blossoms and quite in the same stage of growth, may be collected at the same time on the highest shoulders of Mount Washington, and on the flats at Gor-

ham. The *Linnæa* in this is true to its designation. For as if it belonged to it to support the reputation of the great systematist after whom it is named, it preserves its specific characters with scarcely a tittle of change throughout all its great range. One cannot see this hardy little survivor of the glacial period, so unchanging yet so gentle, so modest yet so adventurous, so wide in its migrations yet so choice in the selection of the mossy nooks which it adorns with its pendant bells, and renders fragrant with its delicious perfume, without praying that we might in these days of petty distinctions and narrow views, be favoured with more such minds as that of the great Swede, to combine the little details of the knowledge of natural history into grand views of the unity of nature.

Another plant which, being less dependent on shade and shelter than the *Linnæa*, mounts still higher, is the cowberry or foxberry (*Vaccinium vitis-Idæa*). This also is both European and American, and is probably a survivor of the Post-pliocene period. It still occurs in at least one locality in the low country of Massachusetts, and on the coast of Maine. It is found along the granitic coast of Nova Scotia, and extends thence northward to the arctic circle, being found at Great Bear Lake and at Unalaska. This too is a most unchanging species, and the same statement may be made respecting *Rubus Chamæmorus*, the cloud-berry, *Empetrum nigrum*, the black crowberry, *Ledum latifolium*, the Labrador tree, *Potentilla tridentata*, the three toothed cinque-foil, which grows on the coast of Nova Scotia, and is found in the nodules of the Ottawa clay, the same in every detail as on Mount Washington, *Vaccinium uliginosum*, the bog billberry, and *V. cæspitosum*, the dwarf billberry. Several of these too it will be observed, are berry-bearing plants, whose seeds must be deposited in all kinds of localities by birds. Yet they never occur in the warm plains, nor do they show much tendency to vary in the distant and somewhat dissimilar places in which they occur. In the case of most of these species, the most careful, comparison of specimens from Mount Washington with those from Labrador, shows no tittle of difference. When we consider the vast length of time during which such species have existed, and the multiplied vicissitudes through which they have passed, one is tempted to believe that it is the tendency of the "struggle for existence" to confirm and render permanent the characters of species rather than to modify them.

Of the more specially arctic plants which have held their ground unchanged on Mount Washington, the following are some of the principal. *Diapensia Lapponica* in beautiful deep green tufts ascends quite to the summit. It occurs also in the Adirondack Mountains, and on Mount Katahdin in Maine. It is found in Labrador, and according to Hooker, extends north to Whale Island in the Arctic seas; but it is not found west of the Great Fish River. It occurs also on the mountains of Lapland, and is described as the hardiest plant of that bleak region. *Arenaria* (*Alsine*) *Grœnlandica*, the Greenland sandwort, adorns with its clusters of white flowers every sandy crevice in the rocks of the very summit of Mount Washington, and is trodden under foot like grass by the hundreds of careless sight-seers that haunt the peak in summer; though I should add that not a few of them carry off little tufts as a memento of the mountains, along with the fragments of mica which appear to form the ordinary keepsakes of unscientific visitors. It is a most frail and delicate plant, seemingly altogether unsuited to the dangerous pre-eminence which it seeks, yet it loves the bare unsheltered mountain peaks, and when it occurs in the more sheltered ravines, has only its stems a little longer and more slender. It occurs on the Adirondack Mountains and on Katahdin, where—if I may judge from specimens kindly sent to me by Mr. Goodale—it attains to smaller dimensions than on Mount Washington, on the Katskills, and at one place on the sea coast of Maine. I have not seen it in Nova Scotia, but it ranges north to Greenland.

Another of the truly arctic plants is the alpine azalea (*Loiseleuria procumbens*), a densely tufted mountain shrub, with hard glossy leaves, that look as if constructed to brave extremest hardships. It is found on the mountains of Norway, at the height of 3550 feet on the Scottish Hills according to Watson, and according to Fuchs at the height of 7000 feet in the milder climate of the Venetian Alps. In America it is found in Newfoundland, in Labrador, and in the barren grounds from lat. 65° to the extreme arctic islands. Gray does not mention its occurrence elsewhere in the United States than the summits of the White Mountains. A member of the same family of the heaths, the yew-leaved phyllodoce (*P. taxifolia*), presents a still more singular distribution. It is found on all the higher mountains of New England and New York, and occurs also on the mountains of Scotland and Scandinavia, but its only known station in northern

America is, according to Hooker, in Labrador. As many as nine or ten of the alpine plants of the White Mountains belong to the order *Ericaceæ*. Another example from this order is *Rhododendron Lapponicum*, a northern European species, as its name indicates, and scattered over all the high mountains of New England and New York, occurring also in Labrador, on the arctic sea coasts, and the northern part of the Rocky Mountains.

It would be tedious to refer in detail to more of these plants, but I must notice two herbaceous species belonging to different families, but resembling each other in size and habit—the alpine epilobium (*E. alpinum* or *alsinefolium*), and the alpine speedwell (*Veronica alpina*). Both are in the United States confined to the highest mountain tops. Both occur as alpine northern plants in Europe, being found on the Alps, on the Scottish Highlands, and in Scandinavia. Both are found in Labrador, and on the Rocky Mountains, and the *Veronica* extends as far as Greenland. The alpine epilobium is one of the few White Mountain plants that have attained the bad eminence of being regarded as doubtful species. Gray notes as the typical form, that with obtuse and nearly entire leaves, and as a variety, that with acute and slightly toothed leaves, which some other botanists seem to regard as distinct specifically. Thus we find that this little plant has been induced to assume a suspicious degree of variability; yet it is strange that both species or varieties are found growing together, as if the little peculiarities in the form of the leaves were matters of indifference, and not induced by any dire necessities in the struggle for life. Facts of this kind are curious, and not easily explained under the supposition either of specific unity or diversity. For why should this plant vary without necessity, and why should two species so much alike be created for the same locality. Perhaps these two species or varieties, wandering from far distant points of origin, have met here fortuitously, while the lines of migration have been cut off by geological changes, and yet the points of difference are too constant to be removed even after the reason for them has disappeared. If this could be proved, it would afford a strong reason for believing the existence of a real specific diversity in these plants.

I have said nothing of the grasses and sedges of these mountains; but one of them deserves a special notice. It is the alpine herd's grass (*Phleum alpinum*), a humble relation of our common herd's grass. This plant not only occurs on the White Moun-

tains, in arctic America, and on the hills of Scotland and Scandinavia, but has been found on the Mexican Cordillera, and at the Straits of Magellan. The seeds of this grass may perhaps be specially suited for transportation by water as well as by land. It is observed in Nova Scotia that when the wide flats of mud deposited by the tides of the Bay of Fundy, are dyked in from the sea, they soon become covered with grasses and carices, the seeds of which are supposed to be washed down by streams and mingled with the marine silt; and fragments of grasses abound in the post-tertiary clays of the Ottawa.

It seems almost ridiculous thus to connect the persistence of the form of a little plant with the subsidence and elevation of whole continents, and the lapse of enormous periods of time. Yet the power which preserves unchanged from generation to generation the humblest animal or plant, is the same with that which causes the permanence of the great laws of physical nature, and the continued revolutions of the earth and all its companion spheres. A little leaf entombed ages on ages ago in the Post-pliocene clays of Canada, preserves in all its minutest features the precise type of that of the same species as it now lives, after all the prodigious geological changes that have intervened. An arctic and alpine plant that has survived all these changes, maintains in its now isolated and far removed stations, all its specific characters unchanged. The flora of a mountain top is precisely what it must have been when it was an island in the glacial seas. These facts relate not to hard crystalline rocks that remain unaltered from age to age, but to little delicate organisms that have many thousands of times died and been renewed in the lapse of time. They show us that what we call a species represents a decision of the unchanging creative will, and that the group of qualities which constitutes our idea of the species, goes on from generation to generation animating new organisms constructed out of different particles of matter. The individual dies but the species lives, and will live until the Power that has decreed its creation shall have decreed its extinction; or until in the slow process of physical change depending on another section of His laws, it shall have been excluded from the possibility of existence anywhere on the surface of the earth.

While the huge ribs of mother earth that project into mountain summits, and the grand and majestic movement of the creative processes by which they have been formed, speak to us of

the majesty of Him to whom the sea belongs, and whose hand formed the dry land, the continuance of these little plants preaches the same lessons of humble faith in the divine promises and laws, which our Lord drew from the lilies of the field.

It is suggestive in connection with the antiquity and migrations of these plants, to consider the differences in this respect of some closely allied species of the same genera. Of the blueberries that grow on the White Mountains, one species, *Vaccinium uliginosum*, is found at Behring's Straits and in northern Europe. *V. cæspitosum* has a wide northern range in America, but is not European. *V. Pennsylvanicum* and *V. Canadense* from their geographical distribution do not seem to belong to the arctic flora at all, but to be of more southern origin. The two bearberries (*Arctostaphylos uva-ursi* and *alpina*), occur together on the White Hills, and on the Scottish and Scandinavian mountains, but the former is a plant of much wider and more southern distribution in America than the latter. Two of the dwarf willows of the White Mountains (*Salix repens* and *S. herbacea*), are European as well as American, but *S. uva-ursi* seems to be confined to America. *Rubus triflorus*, the dwarf raspberry, and *R. Chamæmorus*, the cloud-berry, climb about equally high on Mount Washington, but the former is exclusively American and ranges pretty far southward, while the latter extends no farther south than the northern coast of Maine, and is distributed all around the arctic regions of the Old and New Worlds. It is to be observed, however, that the former can thrive on rich and calcareous soils, while the latter loves those that are barren and granitic; but it is nevetheless probable that *R. triflorus* belongs to a later and more local flora. Similar reasons would induce the belief that the American dwarf cornel or pigeon-berry, (*Cornus Canadensis*), whose distribution is solely American and not properly arctic, is of later origin than the *C. Suecica*, which occurs in northern America locally, and is extensively distributed in northern Europe.

I can but glance at such points as these; but they raise great questions which are to be worked out, not merely by the patient collection of facts, but by a style of scientific thought very much above those which on the one hand escape such problems by the supposition of multiplied centres of creation, or on the other, render their solution worthless by confounding races due to external disturbing causes with species originally distinct. Diffi-

culties of various kinds are easily evaded by either of these extreme views; but with the fact before him of specific diversity and its manifestly long continuance on the one hand, and the remarkable migrations of some species on the other, the true naturalist must be content to work out the problems presented to him with the data afforded by the actual observation of nature, following carefully the threads of guidance thus indicated, not rudely breaking them by too hasty generalisations.

But it is time to leave the scientific teachings of our little alpine friends, and to enquire if they can teach anything to the heart as well as to the head.

The mountains themselves, heaving their huge sides to the heavens, speak of forces in comparison with which all human power is nothing; and we can scarcely look upon them in their majesty, without a psalm of praise rising up within us to Him who made the sea, and from whose hands the dry land took its form. As we ascend them, and as our vision ranges more and more widely over the tops of wooded hills, along the courses of streams, over cultivated valleys, and to the shores of the blue sea itself, our mental vision widens too. We think that the great roots of these hills run beneath a whole continent, that their tops look down on the wide St. Lawrence plain, on the beautiful valleys of New England, and on the rice fields of the sunny south. We are reminded of the brotherhood of man which overleaps all artificial boundaries, and should cause us to pray that throughout their whole extent these hills may rise amidst a happy, a free, and a God-fearing people.

Our alpine plants have still higher lessons to teach. They are fitting emblems of that little flock, scattered everywhere, yet one in heart, and in all lands having their true citizenship in heaven. They tell us that it is the humble who are nearest God, and they ask why we should doubt the guardian care of the Father who cares for them. They witness too of the lowly and hidden ones who may inhabit the barren and lonely spots of earth, yet are special subjects of God's love as they should be of ours. We may thus read in the alpine plants truths that beget deeper faith in God, and closer brotherhood with his people.

The history of these plants has also a strange significance. It might have been written of them, "though the dry land be removed out of its place, and the mountains cast into the midst of

the sea, yet the Lord will not forsake the work of His hands;" for this has been literally their history. In this they hold forth an omen of hope to the people of God in that once happy land through which these hills extend, and who now mourn the evil times on which they have fallen. The mountain plants may teach them, that though the floods of strife should rise even to the tops of the hills, and leave but scattered islets to mark the place of a united land, their rock is sure, and their prayers will prevail. The power that has waked the storm is after all their Father's hand. For years a cry has risen high above these hills: the cry of the bondman who has reaped the fields and received no hire. That cry is sure to be heard in heaven whatever other prayers may go unanswered. An apostle tells us that it enters directly into the ears of the God of Sabaoth, and is potent to call down the day of slaughter on the proud ones of earth. The prayer of the slave has been answered; and the tempest is abroad sweeping away his oppressors and their abettors. Yet God rules in all this, and those whom He has chosen will be spared even like the hardy plants of the hill tops, to look again on a renewed and smiling land, from which many monsters and shapes of dread have forever passed away.

But last of all, the alpine flowers have a lesson that should come near to all of us individually. They tell us how well natural law is observed as compared with moral. Obeying with unchanging fidelity the law of their creation, they have meekly borne the cold and storms of thousands of winters, yet have thankfully expanded their bosoms to the returning sun of every summer, and have not once forgot to open their tiny buds, and bring forth flowers and fruit, doing thus their little part to the glory of their Maker and ours. How would the moral wastes of earth rejoice and be glad, did the sunshine of God's daily favours evoke a similar response from every human heart.